Exploration

Exploration can account for as much as 60% of the cost of a geothermal power project. Research funded by the U.S. Department of Energy is improving exploration techniques and reducing the initial project costs.

Exploration is the First Step

A geothermal resource consists of a concentration of hot water or steam in fractured rocks beneath the Earth's surface. Finding a geothermal resource that has the potential to produce energy competitive with other fuels is a challenging task. Although hot water and steam issue naturally from the ground at many places in the western United States, identifying the more promising underground resources involves the acquisition and interpretation of a complex variety of geologic, geophysical, and geochemical data. Moderate- and high-temperature geothermal resources occur in the more complex geologic settings, where heat, fluid, and fluid flow paths (open fractures) are all present.

DOE researchers are improving techniques, such as core sampling, to analyze and preserve delicate and diagnostic rock features in geothermal reservoirs.

Jeff Hulen, University of Utah/PIX04133

In recent decades the geothermal industry, with strong support from the U.S. Department of Energy (DOE), has made great progress in defining the geothermal resources of the United States. In the early days of geothermal exploration, geologists explored areas with obvious surface geothermal manifestations (geysers, hot springs, and mud volcanoes) in search of economic geothermal systems. These resources have been developed or already tested, and today exploration focuses on deeply buried and concealed geothermal resources. Although large areas in the western United States are favorable for the occurrence of geothermal systems, a productive resource may be less than 1 square mile (2.6 square kilometers) in area. Difficulty in locating a productive resource, economic and land status considerations, and the complexity of subsurface geology, are some of the exploration problems facing geothermal developers.

Research Supported by the U.S. Department of Energy

DOE actively pursues research to improve exploration technology. This research enhances existing methods and develops new methods to reduce costs. Most of the cost of geothermal exploration is related to the great expense of drilling wells, and the strongest effort is directed toward improved location of drilling targets to reduce the number of holes drilled, toward greater information gathered from each drill hole, and toward reduced cost of drilling.

DOE funds cooperative research with the U.S. geothermal industry in field studies of resource areas throughout the world. DOE researchers are working with industry scientists to test new exploration methods and to assess innovative interpretation techniques and improved resource models. This industry collaboration is important in focusing research on the exploration and production problems under field conditions.

Recent studies at The Geysers in California have improved our understanding of the geologic setting, the control imposed on flow of water and steam by faults and fractures, the distribution of permeability in the rocks, and the evolution of the geothermal system. Current studies at Dixie Valley, Nevada, address the formation of alteration mineralogy, the development of faults and fractures and their relation to regional stresses in the Earth, and the local control of fracture permeability and stress distribution in the volume of hot rock containing thermal water. Integrated field studies are also under way at geothermal fields in Coso, California, and Cove Fort

Sulphurdale, Utah. Studies of secondary alteration minerals from drill core of the Tiwi, Philippines, geothermal system have allowed researchers to determine the detailed time and temperature history of the thermal system. A new study of drill core from the Awibengkok, Indonesia, system will determine fracture controls and permeability distribution in the geothermal system.

DOE researchers are improving techniques to analyze the chemistry of minute fluid inclusions (isolated fluid filled cavities or bubbles) in minerals from well samples to determine the evolution of geothermal water, and to estimate temperatures and pressures when the inclusions were formed. Research on electromagnetic methods of exploration has resulted in improved field-survey procedures, greater instrument reliability, and easier and more reliable interpretation mathematics. The basic measurement of temperature in exploration wells was previously limited to 530°F (280°C) because of the melting point of insulation on the wires to the surface recorder. This limitation has recently been removed by the development of tools that measure the temperature and store it in a computer memory in the tool for later use. This combination of temperature measurement and memory eliminates the need for signal wires to the surface and allows the operation to continue at temperatures as high as 752°F (400°C).

Sandia National Laboratories/PIX02270

Sandia National Laboratories' pressure/temperature memory logging tool records temperature and pressure data for as long as 8 hours, surviving in borehole temperatures as high as 752°F (400°C).

Tools of The Trade

Through cooperative exploration, drilling, and research projects with industry, DOE has acquired substantial geothermal databases. The evaluation of the data by DOE researchers has done much to sharpen exploration methods and exploration strategy.

Different types of information are collected by geologists, geochemists, and geophysicists. For example, geologists study surface rocks and samples from drill holes to determine favorable rock types to host the geothermal resources. Geochemists conduct careful analyses of water samples obtained from springs and wells to examine the chemical characteristics that might indicate a geothermal resource, and the comparison of certain elements gives the probable temperature of the thermal water. Geophysicists measure and interpret variations in the Earth's magnetic and gravity fields to determine subsurface rock types, buried faults and fracture zones, and other geologic information.

The Future

The DOE geothermal exploration research program, developed in cooperation with the U.S. geothermal industry, is aiding in the evaluation of potential geothermal fields, developing conceptual models to guide exploration and development, and providing more accurate and reliable tools. The research directly supports the geothermal industry in the United States and in the expanding international geothermal power market.

For more information on geothermal technologies, call the Office of Geothermal Technologies: (202) 586-5340

or visit the Web site:
http://www.eren.doe.gov/geothermal

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